Coal's High Tech Energy Future: Liquids and Gasification

Presentation to Utah Energy Forum,
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Overview

- Gasification
- Coal-to-liquids (CTL)
- Integrated gasification combined cycle (IGCC)
- Comparison of technologies
- Industry status
- What is holding us back?
- $C0_2$ sequestration (EOR, ECBM)

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Gasification Basics

- Gasification does not burn coal
- Coal is subject to hot steam and controlled amounts of air, or oxygen, under high temp and pressure in a reactor
- Carbon molecules break apart to produce hydrogen, carbon monoxide, and other gaseous compounds

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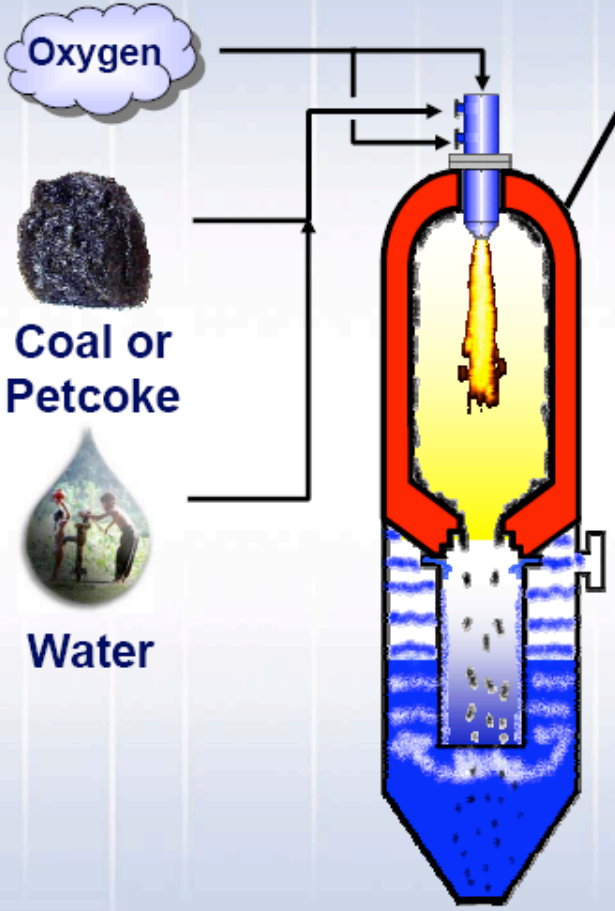
What is Gasification?



- **Controlled Chemical Reaction**
- Up to 1,000 psig or more
- Nominal 2,600 Deg F

Products (syngas):

CO (Carbon Monoxide)

H_2 (Hydrogen)

[CO/H_2 ratio can be adjusted]

Gas Clean-Up Before Product Use!

By-products:

H_2S (Hydrogen Sulfide)

CO_2 (Carbon Dioxide)

Slag (Minerals from coal)

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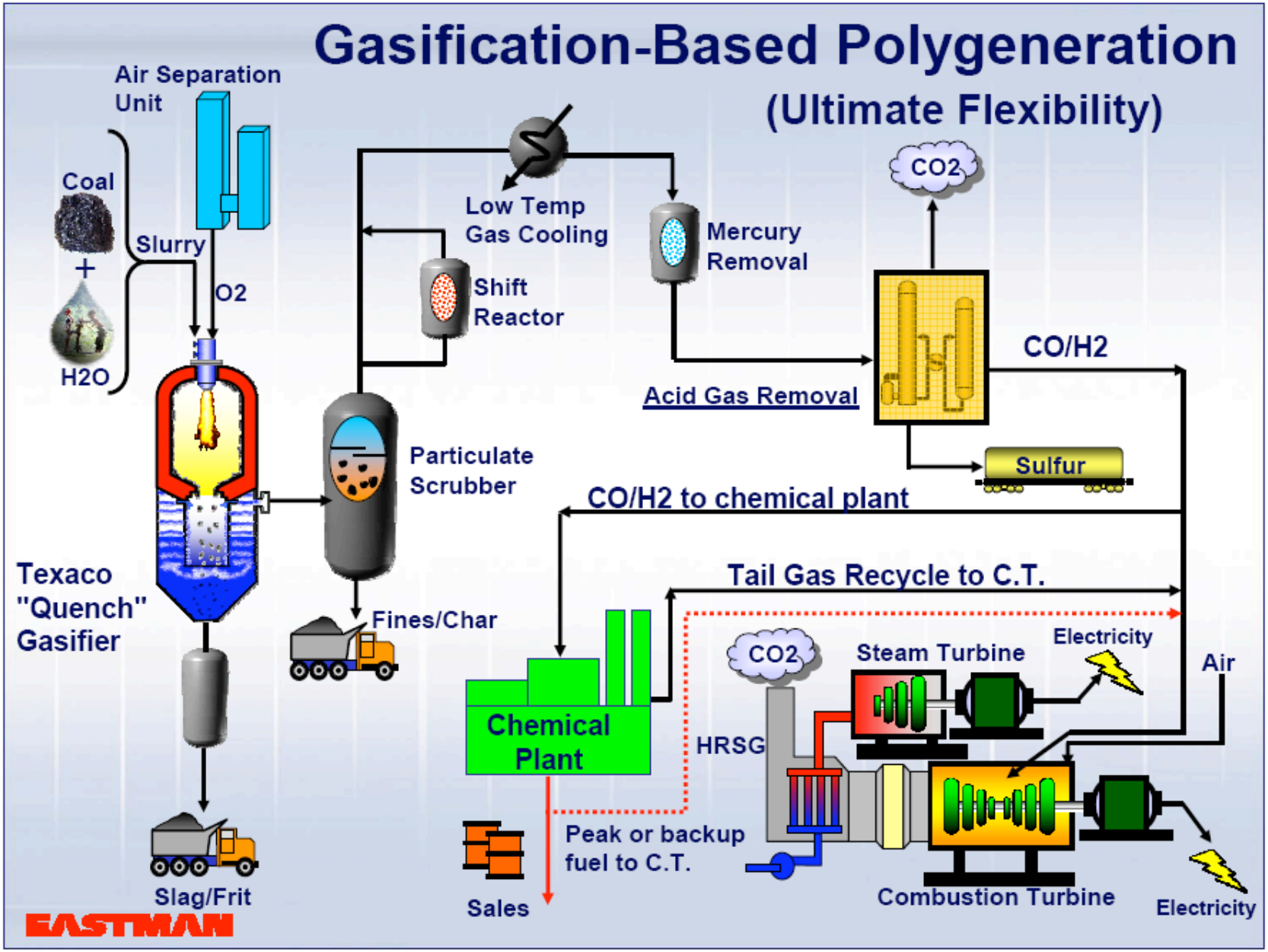
Gasification-Based Polygeneration
(Ultimate Flexibility)
Air Separation Unit
Coal
+
H2O
Slurry
O2
Low Temp Gas Cooling
Shift Reactor
Mercury Removal
CO2
CO/H2
Acid Gas Removal
Sulfur
Particulate Scrubber
CO/H2 to chemical plant
Tail Gas Recycle to C.T.
Texaco "Quench" Gasifier
Fines/Char
Chemical Plant
CO2
Steam Turbine
Electricity
Air
HRSG
Peak or backup fuel to C.T.
Sales
Combustion Turbine
Electricity
Slag/Frit
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Worldwide Gasifiers

Worldwide

- 117 gasification plants; 385 gasifiers
- 35 new facilities in design or construction
- trend is towards IGCC

USA

- 20 gasification plants
- 4 produce electricity
  - 2 use coal
  - Polk County IGCC
  - Wabash River IGCC

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Sasol

- Three Sasol plants in South Africa account for about 30% of world gasifier capacity. They produce transportation fuels and chemicals from coal
- Equivalent of 150,000 bls/day chemicals and fuels including high quality diesel fuel
- Economic in US$35 to $40/bbl range

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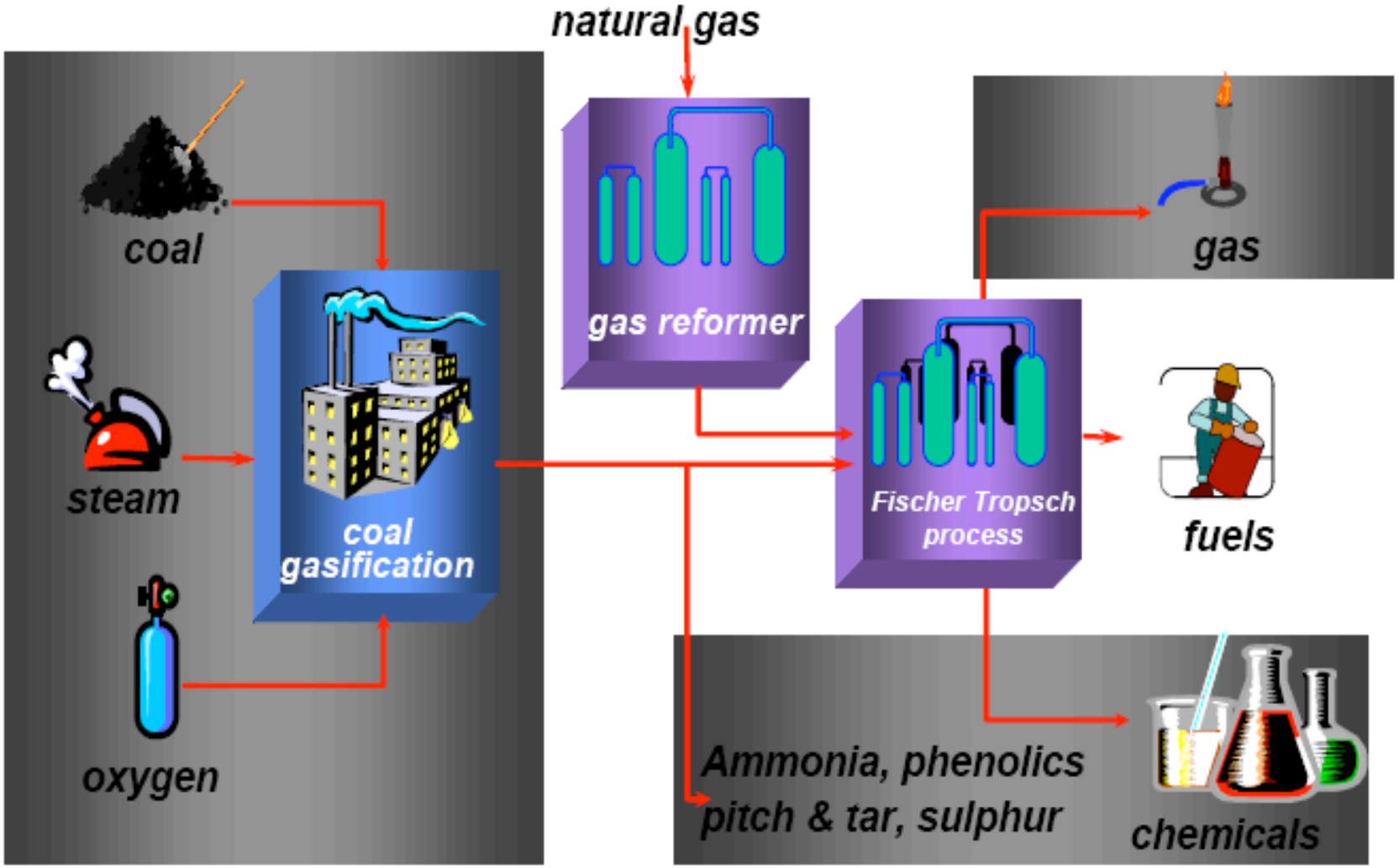
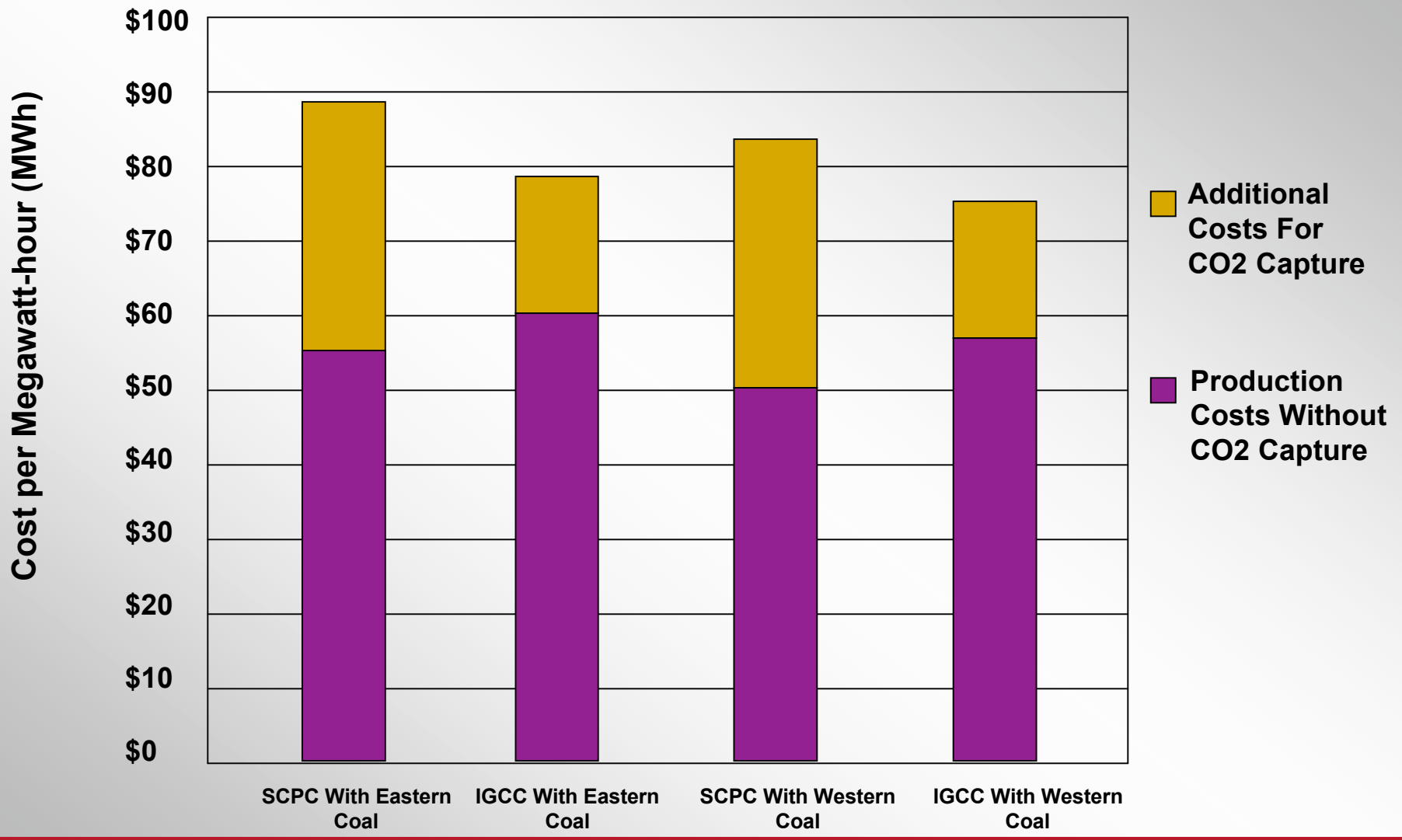
Fischer Tropsch makes Sasol unique: GTL and CTL



IGCC and SCPC with and without Carbon Capture Technology



Source: Public Service Commission of Wisconsin Dept of Natural Resources
June 2006 EGCC Draft Report

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Comparison of IGCC and SCPC

IGCC (disadvantages)

- Higher capital
- Higher operating
- Higher development costs
- Without CO_2 sequestration 7 to 14% higher costs/kWh

IGCC (advantages)

- Half NOx emissions
- Half Sox emissions
- Much better Hg removal
- Inert slag
- 30-50% less water use
- With CO_2 sequestration 9-15% lower costs/kWh
- Future potential for reducing costs as technology matures

Source: Nurula, R, Bechtel Power Corp and Lowe, E., Congress submission 2002

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What's holding us back?

- Costs – initial capital and operating
- Uncertainty on emissions regulations
- Uncertainty on future oil (< $35/bbl)and natural gas prices (<$4/MMBtu)
- Difficult to finance large, multi billion dollar projects

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National Coal Council 2025 Projections

	Coal use (Mt/year)	Capex US$ billions (2005)	Production
Coal-to-liquids	475	$211	2.6 MMbbl/d (50% current US production)
Coal-to-gas	340	$115	4.0Tcf/year (25% current US production)
Coal-to-electricity	375	150	100GW
Coal-to hydrogen	60	$27	10% H2 needs
Coal-to-ethanol	40	$12	
Total	1,300	$515	

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What will accelerate gasification, IGCC and CTL investments?

- Government assistance (tax credits, loan guarantees, creative financing incentives etc E[illegible]Policy Act 2005, Coal-to-liquids [illegible]omotion Act of 2006)
- Need more full scale projects (reduce capital and increase availability)
- CO_2 related legislation

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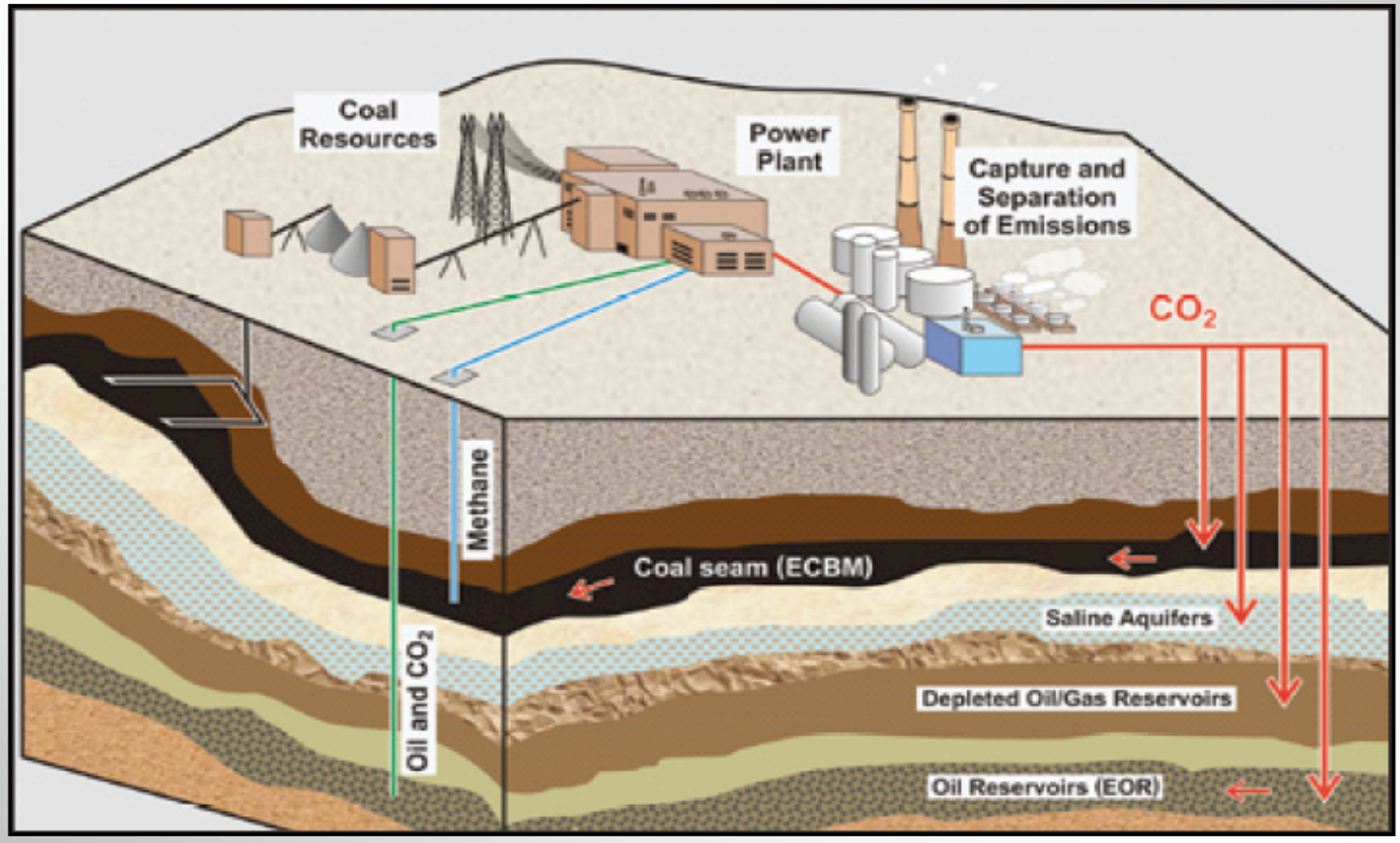
CO_2 Sequestration



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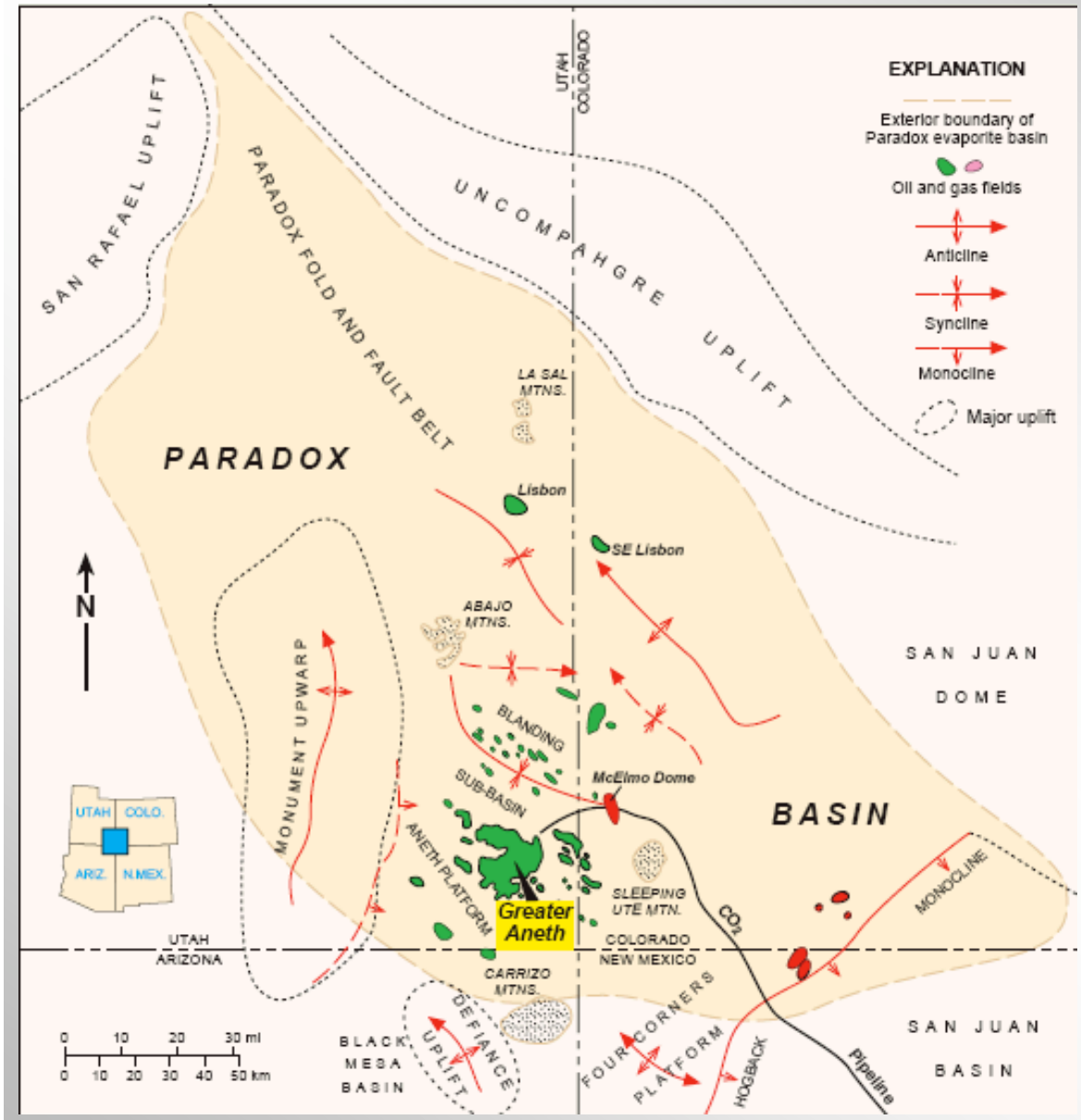
DOE CO_2 pilot project in SE Utah



Anasazi field was chosen as the best candidate for a pilot CO_2 flood demonstration project after reservoir simulations were completed on both the Anasazi and Runway fields.

http://geology.utah.gov/emp/co2sequest/pdf/poster0506_a.pdf

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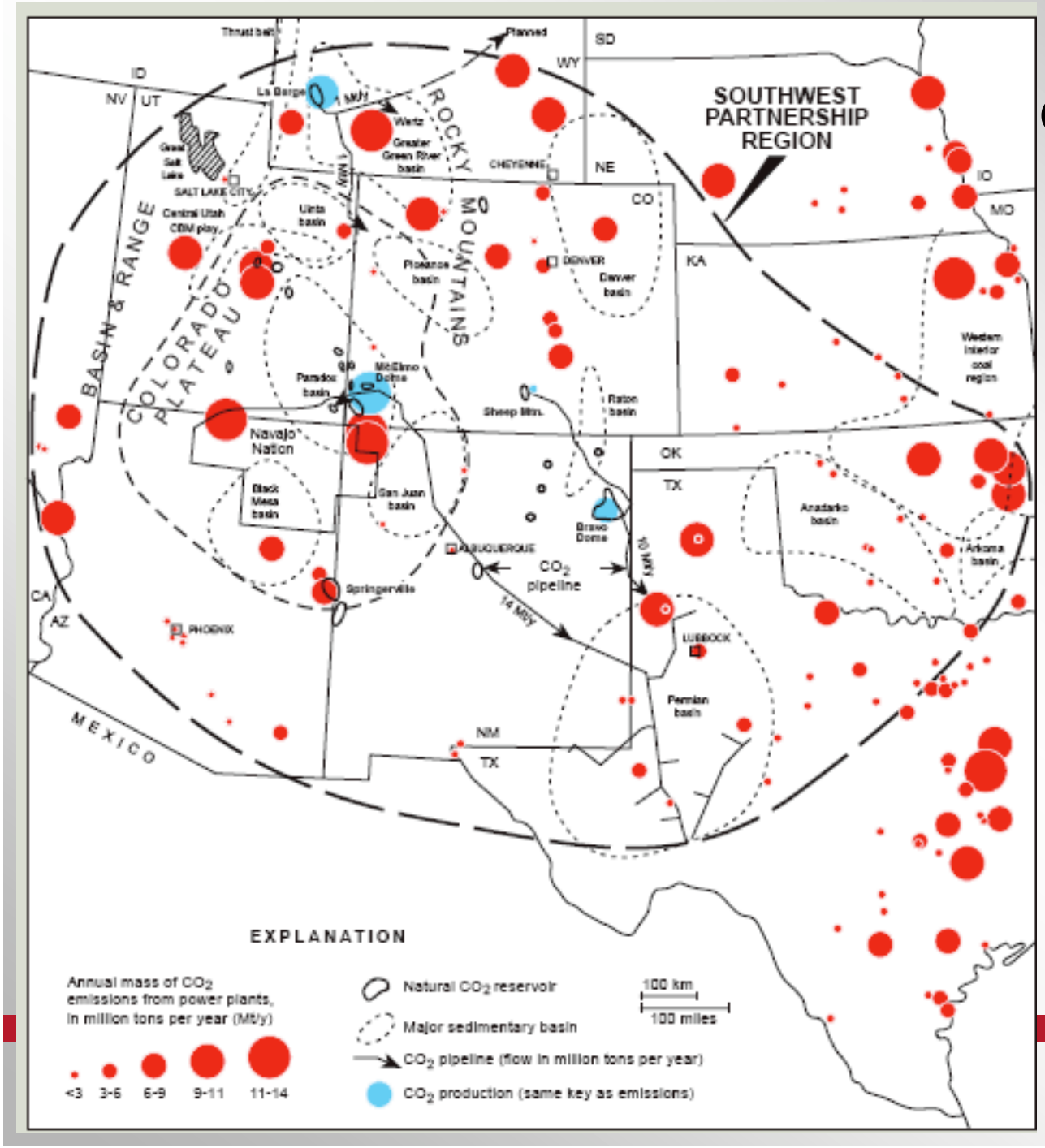
Western Power Plant CO_2 Emissions and CO_2 Production/Pipelines



Source: Chidsey, Allis et al, Utah Geological Survey 2003

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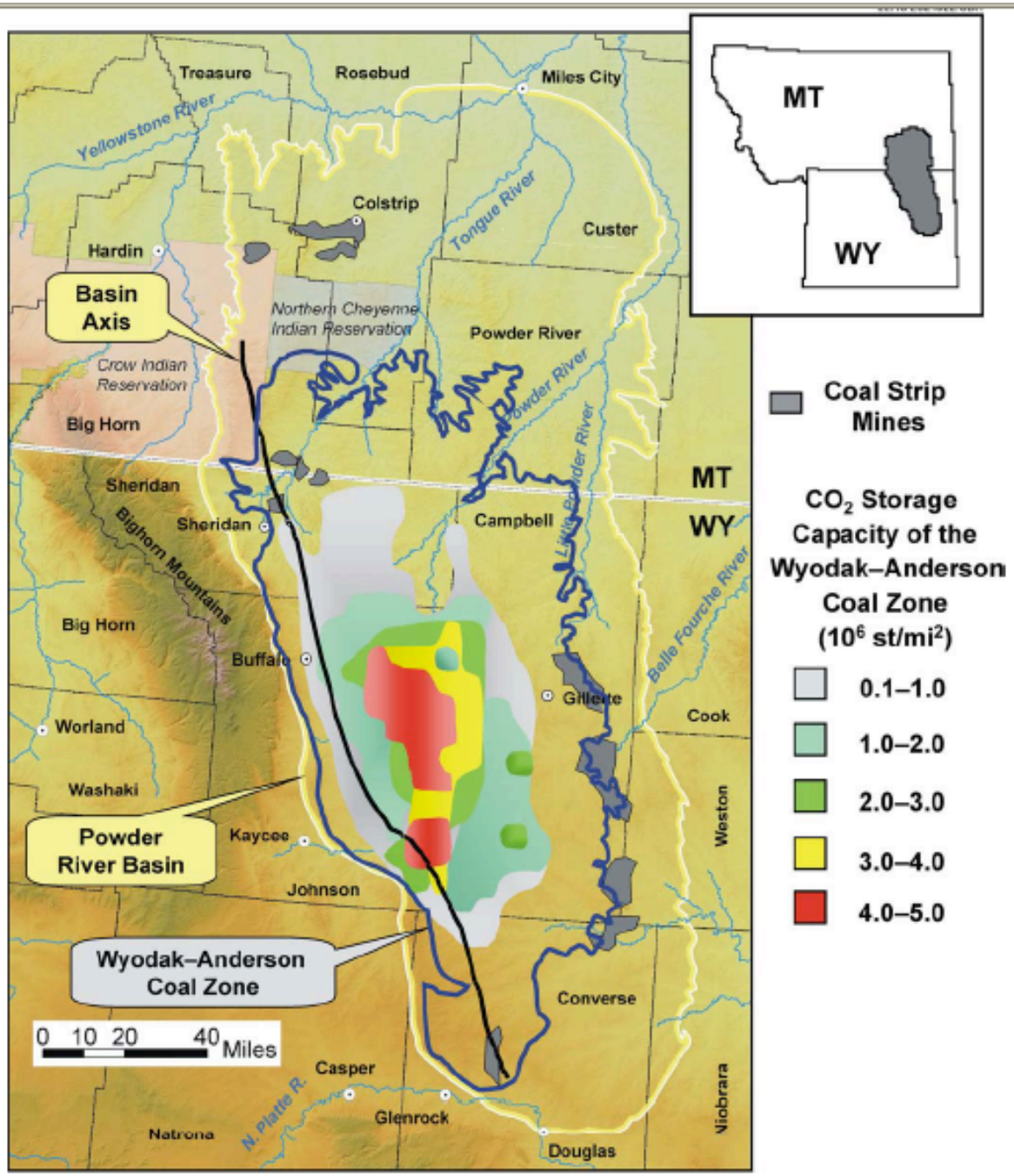
ECBM Potential in Powder River Basin



Source: Nelson, C.R. et al, Plaine CO_2 Reduction Partnership

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What does Utah have to offer?

- Reserve base of high quality coal
- History of coal mining and good labor force
- High rank coal (good for IGCC)
- Supportive state government
- Good sources for CO_2 sequestration including Enhance Oil Recovery (EOR) and Enhanced CBM (ECBM) sites

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Summary

- Gasification, CTL and ICGG similar technologies
- Proven technologies
- Higher cost, higher risk without incentives
- Energy security, local jobs,
- Look North Alberta oil sands
- What happens after 2008? McCain Clinton?
- Utah could be a preferred location for these technologies

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Answers to questions (post presentation)

1. What are the quality characteristics of diesel produced from coal?

Example – Ultra Clean Diesel from Rentech FT Process

FT Fuel Comparison Characteristics

	Low Sulfur D-975	California CARB	Rentech (FTD)	EU (2005)	EPA (2006)
Cetane Index	>40	>48	72	>50	>40
Aromatics	<35	<10	<4	<10	<35
Sulphur	<500	<500†	<1	<10	<15
Biodegradable	NO	NO	YES	NO	NO

† Note: In 2006, US regulations will require <15 ppm sulphur

FTD from coal is an "alternative fuel" under 1992 Energy Policy Act (EPACT)

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Answers to questions (post presentation)

2. What % of CO_2 can be retained in underground storage?

- **Leakage rates of 50% can be expected in EOR projects where the primary goal is to push out the oil**
- **In reservoirs designed to store CO_2 retention rates of exceeding 99% can be expected**
- **Recent Australian work is proposing >99% retention over 1000 years**
- **IPCC (UN Agency) Special Report concluded that "at least 99% retention is likely for well selected and managed storage sites"**

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References for last two slides:

- 1. Clark, P 2006, “The future of coal – carbon feedstock gasification” paper to CIM annual meeting May 2006
- 2. Benson S.M. 2006 “Monitoring Carbon Dioxide Sequestration in Deep Geological Formations for Inventory Verification and Carbon Credits”, SPE Annual Conference Sept 2006.

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